

Wood pellet market and trade: a global perspective

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Abstract: This perspective provides an overview of wood pellet markets in a number of countries of high significance, together with an inventory of market factors and relevant past or existing policies. In 2010, the estimated global wood pellet production and consumption were close to 14.3 Mt (million metric tonnes) and 13.5 Mt, respectively, while the global installed production capacity had reached over 28 Mt. Two types of pellets are mainly traded (i) for residential heating and (ii) for large-scale district heating or co-firing installations. The EU was the primary market, responsible for nearly 61% and 85% of global production and consumption, respectively in 2010. EU markets were divided according to end use: (i) residential and district heating, (ii) power plants driven market, (iii) mixed market, and (iv) export-driven countries. North America basically serves as an exporter, but also with significant domestic consumption in USA. East Asia is predicted to become the second-largest consumer after the EU in the near future. The development perspective in Latin America remains unclear. Five factors that determine the market characteristics are: (i) the existence of coal-based power plants, (ii) the development of heating systems, (iii) feedstock availability, (iv) interactions with wood industry, and (v) logistics factor. Furthermore, intervention policies play a pivotal role in market development. The perspective of wood pellets industry was also analyzed from four major aspects: (i) supply potential, (ii) logistics issues, (iii) sustainability considerations, and (iv) technology development. © 2013 Society of Chemical Industry and John Wiley & Sons, Ltd

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General introduction

Wood pellets were initially produced to serve as an alternative for oil, particularly for heating, as they contain high fuel density and quality. For this reason, the wood pellet market has strong connection with fossil fuel prices which limits its growth. In recent years, as a result of the EU objective to increase the share of renewable energy, the wood pellet industry is now becoming prosperous again. More wood pellets are being traded, not only on a global scale, but also in a much larger volume. The trade volumes of wood pellets between EU and non-EU countries in 2010 is about 45 PJ¹, which is comparable to biodiesel (about 75 PJ) and bioethanol (about 16–22 PJ).^{2,3}

The development of the wood pellet industry is largely influenced by market characteristics and public policies. The market is shaped by a diverse group of factors such as resource availability, geographical characteristics, climate, and other economic factors. These market elements are intertwined with the intervention of a variety of national and regional policies, weaving a complex trading web. All of these factors not only vary by country or regions, they also strongly link to other sectors, and give various impacts to wood pellet trade and market. This considerable complexity suggests a need to gain more insight into individual wood pellet markets as well as to investigate the interrelation between this wide range of factors and trading patterns.

Over the years, IEA Bioenergy Task 40⁴ has carried out numerous detailed studies on international bioenergy trade, in which wood pellet industry development is always one of the major focuses. Lamers *et al.*¹ have also reported the up-to-date developments in international solid bioenergy trade, including quantification of wood pellets trade flows. Sikkema *et al.*⁴ performed a detailed study at European level. At present, there are still no studies that compile a comprehensive inventory of country-specific wood pellet markets in connection with relevant policies and market factors. Therefore, at the end of 2011, Cocchi *et al.*⁵ have compiled a report which comprises an overview of the wood pellet market in Europe and North America at country level, the perspectives of domestic use and trade of wood pellets in emerging markets (Asia and Latin America), and the challenges for ensuring a sustainable pellet trade.

This perspective is based on Cocchi *et al.*⁵ with additional comments and complemented with a tabulated inventory and analysis of relevant past or existing policies and market factors. We refer the reader to Cocchi *et al.*⁵ for the complete set of data and more detailed information.

Methodology

The scope of this study is to provide an overview of wood pellet markets in a number of countries of high significance, and of how the market was affected by policies and market factors. The data presented in this perspective were originally collected from several in-depth studies, particular country reports, performed by Task 40 members,[†] mainly built on national statistics and interviews with stakeholders.⁶ The data collection was complemented by a thorough contextual literature search whenever required, including utilizing international databases such as EUROSTAT.^{‡7} Some discrepancies were observed between EUROSTAT trade data and the data provided by country specific sources (associations, national experts, Task 40 members, etc.), therefore the data presented in this perspective should be regarded only as indications.

The wood pellet market is primarily influenced by the implementation of specific support, indirect policies (especially of energy and sustainability), and several other market factors such as resource availability, geographical factors, climate, and other economic factors. An inventory and analysis of market factors and relevant past or existing policies were compiled. The information were extracted from Cocchi *et al.*⁵ categorized accordingly, and linked with their respective direct and indirect effects on wood pellet markets, by taking the production and consumption developments over time as indicators. These were presented according to specific countries in Table 1. A cross-check with direct information from trade actors was performed to guarantee the significance of the respective policy or market factor. If negative factors (barriers) were mentioned, they were further categorized

^{*}IEA Bioenergy Task 40 was established under the International Energy Agency (IEA) Bioenergy Implementing Agreement in December 2003, and focuses on international bioenergy trade and its wider implications. It currently has 14 member countries. For more information www.ieabioenergy.com and www.bioenergytrade.org

[†]Task 40 currently consists of 14 member countries which represented by public and private institutions: Austria, Belgium, Brazil, Canada, Denmark, Finland, Germany, Italy, Japan, The Netherlands, Norway, Sweden, United Kingdom and United States. See here for the country reports: <http://bioenergytrade.org/reports/country-reports-2010/index.html>

[‡]Eurostat is the statistical office of the European Union situated in Luxembourg. Its task is to provide the European Union with statistics at European level that enable comparisons between countries and regions. <http://ec.europa.eu/Eurostat>

Table 1. Market characteristics, policies/regulatory framework and market trend.

Country	Market characteristics	Policies / Regulatory framework	Market trend
Europe – Mixed market			
Denmark	Import-based market – lack of raw materials	<ol style="list-style-type: none"> 1. Tax exemptions on pellets 2. The utilities are forced by Government decree to use bio-mass in large amounts 	<ol style="list-style-type: none"> 1. Large CHP plant Avedøre Unit 2 using wood pellets – Import increases rapidly since 2010 (near to 2-fold) 2. Increased consumption in both power plants, public buildings and the residential sector
Poland	<ol style="list-style-type: none"> 1. Coal-based energy market (by power plants, district heating systems and individual heating systems) 2. Rising prices of fossil fuels, as well as the risk of unstable deliveries 	<ol style="list-style-type: none"> 1. Green and Red certificates 2. Legal regulations promoted the use of agricultural biomass 3. Legal duties concerning the compulsory production of green energy 	<ol style="list-style-type: none"> 1. CHP plants started to co-fire biomass with coal 2. Extensive investments in pellets production within last years 3. Increase % of agricultural biomass in power plants using biomass 4. Growth of domestic consumption 5. Increased interest of both district heating companies and CHP plants in biomass utilization
Sweden	<p>Opportunities:</p> <ol style="list-style-type: none"> 1. High oil prices, increasing electricity costs, and heavy taxation on fossil fuels <p>Barriers:</p> <ol style="list-style-type: none"> 1. High raw material prices and intense competition 	<ol style="list-style-type: none"> 1. Electricity certificate system combined with renewable obligations and exemptions from CO₂ taxes 2. <i>Indirect effect:</i> Heavy fossil fuels tax 	<ol style="list-style-type: none"> 1. Use of wood pellets in private households has increased by a factor of 20 over a 13-year period 2. Raw material shortage
Europe – Residential and district heating			
Austria	Long tradition to use wood for space-heating and related familiarity with this fuel	Financial support for installing a wood pellet system (previously is called 'Holzwärme')	Increased use of wood pellets for residential heating
Germany	No co-firing of wood pellets in power plants – rely on other renewable electricity such as solar, wind and other biomass power	<ol style="list-style-type: none"> 1. Market incentive programme (MAP) – investment subsidy 2. Renewable Energies Heat Act (EEWärmeG) – building regulation 	<ol style="list-style-type: none"> 1. Increased use of wood pellets for residential heating 2. Depletion/Freezing of MAP budget caused uncertainties among the investors leading to a smaller number of pellet heating systems installed in 2010. 3. Reinforced utilization of pellets on the small-scale market 4. The pellets produced for power generation are entirely exported
France	<p>Opportunities:</p> <ol style="list-style-type: none"> 1. Potential availability of raw material is high, but sawmills are small and sawdust resources are dispersed in a large territory 2. The northeast part of France has a continental climate with long and cold winters and a strong tradition to use wood energy <p>Barriers:</p> <ol style="list-style-type: none"> 1. Cheaper prices of other sources of energy like gas and electricity 2. Nuclear power oriented electricity production 	<ol style="list-style-type: none"> 1. Focused on improving wood log uses by householders and on the development of heating or cogeneration units burning wood chips 2. Some tax relief for high efficiency stoves and boilers 3. Some regional support to the wood pellet 4. <i>Indirect effect:</i> Promotion of nuclear energy 	<ol style="list-style-type: none"> 1. Lack of support measures at national level: continuous but slow wood pellets market growth 2. Faster market development in the north-east part of France

Table 1. (Continued).

Country	Market characteristics	Policies / Regulatory framework	Market trend
Italy	<ol style="list-style-type: none"> 1. The economic competitiveness of wood pellet versus other fuels such as LPG and heating oil that are still the main fuels used in several decentralized rural areas not served by the natural gas grid network 2. The presence of a mature and dynamic sector of stove manufacturers providing a wide range of solutions from entry level to high design products 3. Over 15 million traditional systems (fireplaces, wood ovens, boilers, etc.) still operating with very low efficiencies 4. Relatively higher abundance of raw material and a more developed wood industry in the northern region <p>Barriers:</p> <ol style="list-style-type: none"> 1. Rising competition of other manufacturing activities such as that of fiberboards and furniture, but also to the increasing competition of a growing number of biomass plants, that in some cases have led to a concentrated demand of feedstock in some local areas 	<ol style="list-style-type: none"> 1. Energy efficiency certificates (white certificates) 2. Tax relief for energy saving in buildings 3. Mandatory quota of RES for new buildings 4. At municipality level: loan guarantee fund, incentives for RES heating and energy efficiency in small scale applications, measures for the modernization of the system of energy efficiency certificates (white certificates). 	<ol style="list-style-type: none"> 1. Stimulated demand of biomass energy in the heating sector and promote the installation of new biomass units (boilers, district heating network, pellets stoves etc.) 2. Market expansion – despite the increasing trend of pellet prices, the annual costs of a pellet stove are still as competitive as a traditional natural gas boiler 3. The potential for growth in the domestic market is still quite high, and lies in the possibility of replacing old and inefficient traditional wood heating systems with modern stoves and boilers 4. Over 70% of the production is located in the northern region <p>Due to the barriers:</p> <ol style="list-style-type: none"> 1. Some large producers closed their plants in 2009–2010 due to economic crisis and difficulties in sourcing feedstock at competitive prices 2. Increasing number of operators shifted their main activity from the production to the distribution of imported pellets. 3. Some large players entered the market, i.e. Italiana Pellets 4. Large quantity of import to cover the demand
Finland	<p>Opportunities:</p> <ol style="list-style-type: none"> 1. Large timber production – large amount of by-products <p>Barriers:</p> <ol style="list-style-type: none"> 1. Competition with other energy production (bark in CHP) and wood panel and pulp production (sawdust) 2. Not competitive with heavy fuel oil or coal as fuel in heating and power plants – high investment in boilers 3. Domestic pellet consumers have to compete for pellets with the consumers in the export countries 4. Higher taxation of fossil fuels in energy production and subsidies for electricity from biomass in main exporting countries (Sweden, Denmark, NL, UK) 5. After 2008, raw material shortage and increased price of raw material in pellet mills 		<ol style="list-style-type: none"> 1. Mainly used in applications where light fuel oil is an alternative fuel, typically in the heating of dwellings and small public or industrial buildings. 2. Before 2008, favored exportation of pellets from Finland to Sweden and Denmark. 3. After 2008, increased raw material price and lowered world market price of pellets caused several mill stoppages and decrease production

Table 1. (Continued).

Country	Market characteristics	Policies / Regulatory framework	Market trend
Norway	<p>Opportunities:</p> <ol style="list-style-type: none"> 1. Vast wood resources compared to the number of inhabitants <p>Barriers:</p> <ol style="list-style-type: none"> 1. Based the electricity production on hydro power (96%) – 51% of the net domestic energy consumption 2. No coal plants 3. Relatively high share of wood stoves that are used in combinations with electric heating and/or heat pumps in residential heating 4. Preferences for wood chips in a relatively small market for district heating due to lower fuel costs and business opportunities for local forestry 5. Strong competition – lower electricity prices, caused by increased production of renewable electricity 	<ol style="list-style-type: none"> 1. A joint green certificate market with Sweden 	<ol style="list-style-type: none"> 1. No co-firing due to no coal plants 2. Small pellet market for residential heating
Europe – Power plants driven market			
Belgium	Limited availability of domestic forest resources	<ol style="list-style-type: none"> 1. The Green Certificate Scheme (GEC) 2. Fiscal reduction for residential heating and for enterprises 3. Supports for ecological investments (FI Reg) 	Stimulate the demand for solid bio-fuels, including pellets, to generate electricity in (co)combustion, which is largely satisfied by pellet imports (1 GEC = 1 MWh).
The Netherlands	1. Limited availability of the main feed-stock for wood pellets (sawdust from wood processing industry)	<ol style="list-style-type: none"> 1. Financial support for electricity generated on biomass (MEP, SDE and SDE+ support schemes) 2. Mandate co-firing of biomass at all coal-fired power stations (still in discussion) 	<ol style="list-style-type: none"> 1. Increasing use of wood pellets in power plants 2. Large quantity of import (>90%) 3. No further increase in domestic production capacity is expected 4. Origins of future solid biomass imports will further diversify
United Kingdom	Transparent monitoring of biomass energy use and sustainability certification by Ofgem	<ol style="list-style-type: none"> 1. Renewable Obligation 2. Electricity Market Reform 3. Feed in Tariff 	Increasing use of wood pellets, largely in power plants
Europe – Export oriented countries			
Baltic states	<p>Opportunities:</p> <ol style="list-style-type: none"> 1. Foreign investments and (due to) increasing demand in the Baltic Sea Region (Sweden, Denmark etc.) 2. Relatively low costs of production (raw material, salaries and energy); 3. Big ports for pellet transport in Sillamae (Estonia), Klaipeda (Lithuania), Liepaya, Vetspils (Latvia), and Paldiski (Estonia). <p>Barriers:</p> <ol style="list-style-type: none"> 1. Lack of domestic equipment producers / consultants / experts; 2. Lack of easy and good quality supply chain for any target group 3. Lack of big domestic consumers 	Feed-in-tariff in Latvia (power plants), Estonia (CHP) and Lithuania (solid/gasification) for electricity production from biomass	<ol style="list-style-type: none"> 1. Closely related to market development in the Baltic Sea Region 2. Based on Scandinavian experience 3. Export oriented – very small domestic market

Table 1. (Continued).

Country	Market characteristics	Policies / Regulatory framework	Market trend
Russia	<p>Opportunities:</p> <ol style="list-style-type: none"> 1. Huge amount of cheap raw material 2. Potential for biofuel raw material from waste timber is very high 3. Utilization rate of Russian forests is low 4. North West region - presence of rich wood resources and geographical closest of this region to EU <p>Barriers:</p> <ol style="list-style-type: none"> 1. Lack of wood-transporting roads 2. Lack of specialized cargo handling capacity and consequently, a high cost of transshipment. 	<ol style="list-style-type: none"> 1. Export tax system for round wood 2. Russian Wood Pellets (RWP) plan 	<ol style="list-style-type: none"> 1. Majority part of pellet mills is located in North-West Federal District 2. Large projects such as 'Vyborg Cellulose' (Leningrad oblast) and 'Region-Russian Wood Pellets' 3. it is plausible that additional round wood is harvested for wood pellet production
North America			
Canada	<ol style="list-style-type: none"> 1. Searching for new sources of socioeconomic growth following the winding down of the Canadian pulp industry 2. Mountain pine beetle infestation – availability of large quantity of dead wood 3. Market dried up in the North East US 4. Unforeseen fall in the value of Euro relative to Canadian dollar, results in squeezed profits <p>Barriers:</p> <ol style="list-style-type: none"> 1. In 2008, severe downturn in the US housing market and subsequent decline in lumber demand has caused shortage of mill residues. 2. Rich oil and natural gas resources – has developed a wide infrastructure for distribution 3. Pellets production is in the interior (400–600 km from ocean ports) 		<ol style="list-style-type: none"> 1. Export oriented - highly influenced by US and European market 2. Small domestic market 3. Short-term loss of US and European markets caused Canadian suppliers to seriously address the opportunity to develop domestic pellet market 4. In 2008, due to shortage of mill residues, pellets production declined
United States	<ol style="list-style-type: none"> 1. Many underutilized sources of biomass – mill residues and crop residues 2. Reliance on sawmill residues 3. Increases in the cost of fossil energy 4. Demand and also investment from Europe 	<ol style="list-style-type: none"> 1. Federal level: Renewable Energy Production Incentive (REPI) 2. State biomass economic drivers 	<ol style="list-style-type: none"> 1. Over 80% of pellets produced in the USA were used domestically (1.6 MT); of the remaining, were exported to Europe (0.4 MT) 2. Production declined when the sawmilling sector retrenched in the 2008–2009 recession 3. New mills to process chipped roundwood – independence from the sawmill industry has allowed a focus on export 4. Regulations will likely drive existing coal power plants to co-fire with biomass, which will create an increasing market for biomass pellets
East Asia			
Japan	<ol style="list-style-type: none"> 1. Lack of raw material 2. Lack of sufficient policy support 3. Lack of technical quality standards 	<p>Renewable Portfolio Standard (RPS) scheme designed to promote the usage of renewable energy.</p>	<ol style="list-style-type: none"> 1. Large-scale imports of wood pellets – strong further growth is anticipated 2. Policy requires electricity retailers to source a minimum percentage of their electricity from renewable energy sources. The scheme is flexible and allows for the use of a variety of renewable energy sources, including biomass, and consequently Japanese power utilities are now considering the usage of energy wood pellets

Table 1. (Continued).

Country	Market characteristics	Policies / Regulatory framework	Market trend
South Korea	Large coal power plants	<ol style="list-style-type: none"> 1. Renewable portfolio standards for power companies (by 2012) 2. Korea Forest Service subsidize the purchase of domestic pellet boilers by 60–70% 	<ol style="list-style-type: none"> 1. Possibility to co-fire wood pellets with coal 2. Expected that at least 60% of renewable energy will be from pellets, amounts to 2.25 Mt in 2012 3. Induce pellets production in Indonesia, Myanmar and New Zealand 4. About 13 600 boilers were installed since 2008
Oceania			
Australia		1. Lack of incentives and long-term policy certainty	1. The potential for heat and power from pellets in Australia is huge but is yet to be fully realized
New Zealand	Wood energy provides about 5% of New Zealand's total energy supply. Wood energy is mainly used by the timber industry, which burns residue wood to provide heat energy. Residential wood burners and open fires account for over 20% of wood energy in New Zealand.	The Energy Efficiency and Conservation Authority is administering the Wood Energy Grant Schemes (WEGS) which aims to increase the use of wood residues as an energy source for industrial use.	<ol style="list-style-type: none"> 1. The supply potential is high (about 0.5 Mt annual production by 2020) 2. There are opportunities to significantly increase the use of wood as an energy source

to avoid confusion. Due to the scope of this paper, the analysis was limited to a number of selected countries. Countries with relatively small wood pellet market were included in Cocchi *et al.*,⁵ but not included in this perspective.

An overview of the wood pellet market

In 2010, the global wood pellet production reached 14.3 Mt, while the consumption was close to 13.5 Mt. Figure 1 shows the production and consumption of wood pellets by country. The worldwide production capacity and average size of pellet plants also shows an increasing trend, recorded an impressive 22% increase from 2009. Figure 1 shows the wood pellet production and consumption by country in 2010. Figure 2 depicts the wood pellet production capacity by country (2009–2010) while Figure 3 depicts their utilization rate, i.e. the ratio of annual production to total production capacity (%). Two types of pellets are mainly traded – high-quality pellets (white pellets) which are supplied in bulk or bagged to the residential heating market; and industrial-quality pellets (brown pellets) derived from low(er) value feedstock which are used by large-scale district heating and co-firing installations.

Europe

The European Union is still the primary market for wood pellets and will remain as such for the next several years. The production in 2010 equals to 61% of the global production, where the consumption equals to nearly 85% of the global wood pellet demand. The gap between production and consumption in EU has been growing with more than an 8-fold increase.

In general, prices of white pellets show seasonal variations with higher prices during the heating period and lower prices in summer. In certain countries, wood pellet prices increased significantly in 2009 and remained stable in 2010, such as Germany, Austria, and Sweden. In Sweden, wood pellet prices increased about 18% in 2009 and remained the same in 2010. In contrast, wood pellet prices in Denmark are rather stable since 2007, maintained at €208/tonnes (25% VAT included) for district heating plants. On the other hand, price development of wood pellets in Finland shows a stable increase since 2002. Price data of industrial pellet are rather difficult to analyze, as the large majority of the wood pellets is traded under long-term bilateral contracts at fixed (unknown) prices. However, prices of pellets imported from non-EU countries generally dropped in 2010 due to financial difficulties in several EU countries, given that EU is the largest market for industrial pellets.

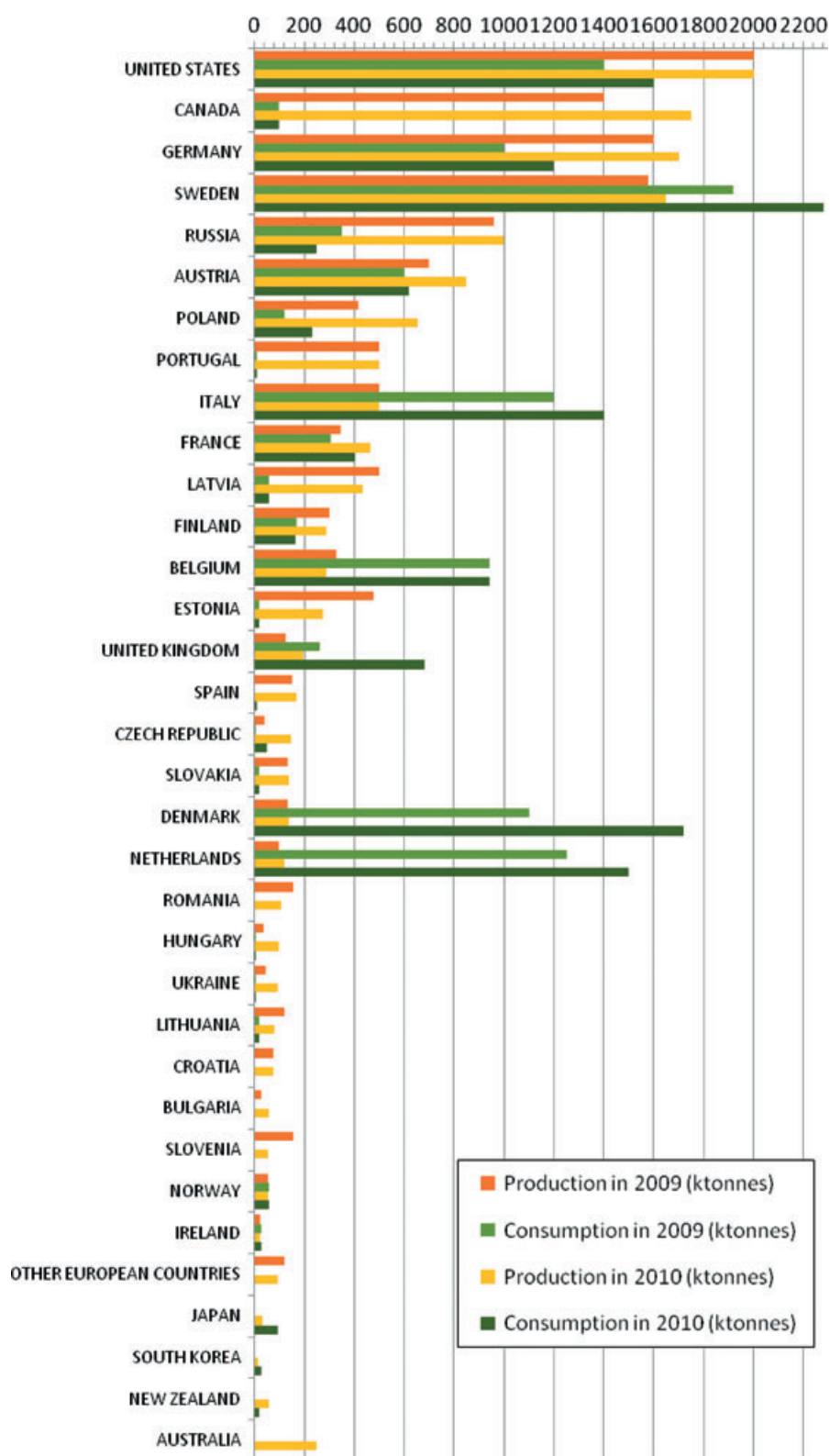


Figure 1. Wood pellet production and consumption by country in 2009 and 2010.

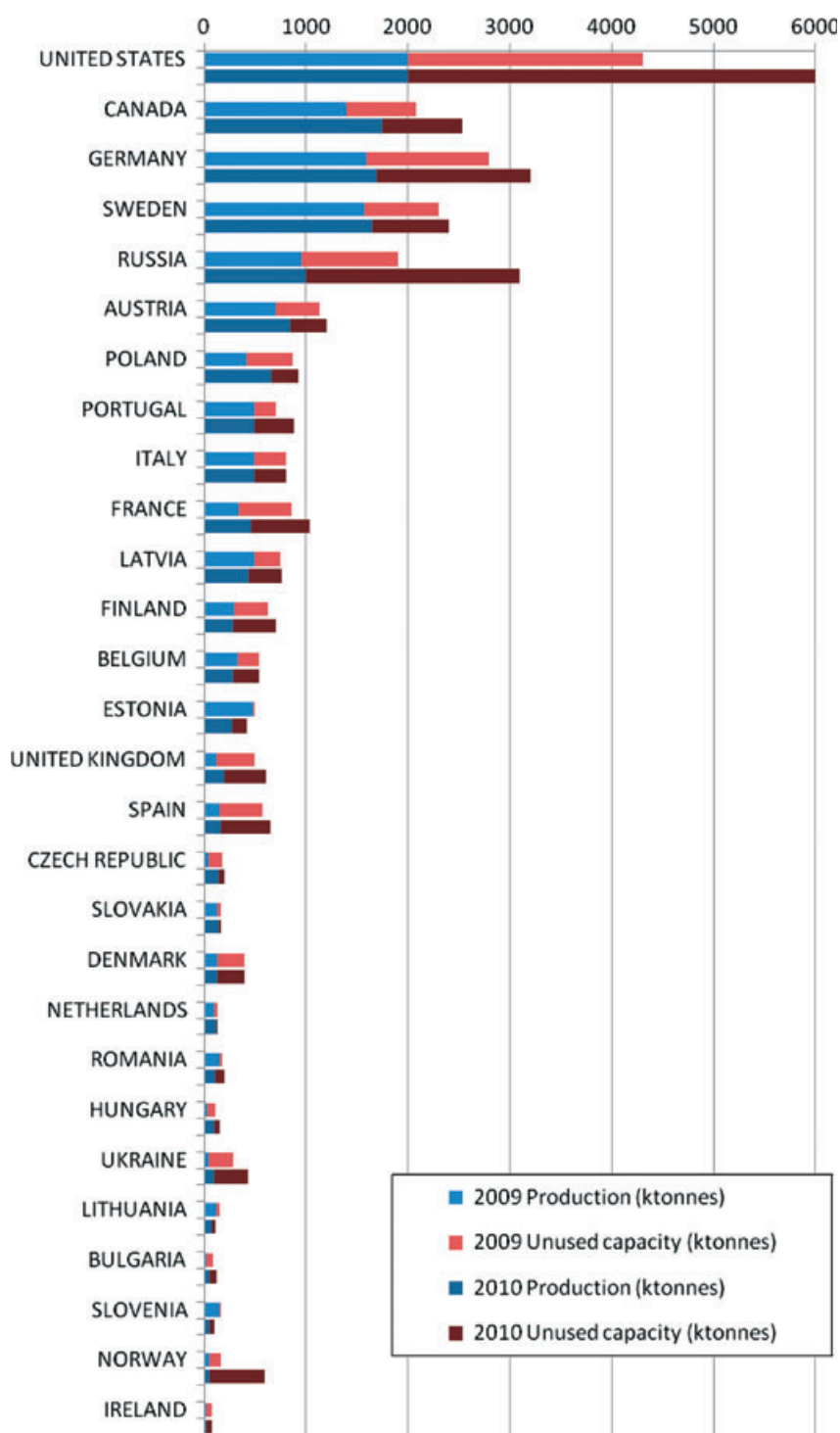


Figure 2. Wood pellet production capacity by country (2009–2010).

Residential and district heating – Germany, Austria, France, Italy, Finland, and Norway

In the segment of residential heating, the main drivers for market expansion are often indirect support measures for

the installation of pellet stoves and boilers to improve the relative cost competitiveness of wood pellets compared to traditional fuels such as LPG heating oil and natural gas, especially in rural areas that are not yet served by gas grids. With such supportive policies, the wood pellets in

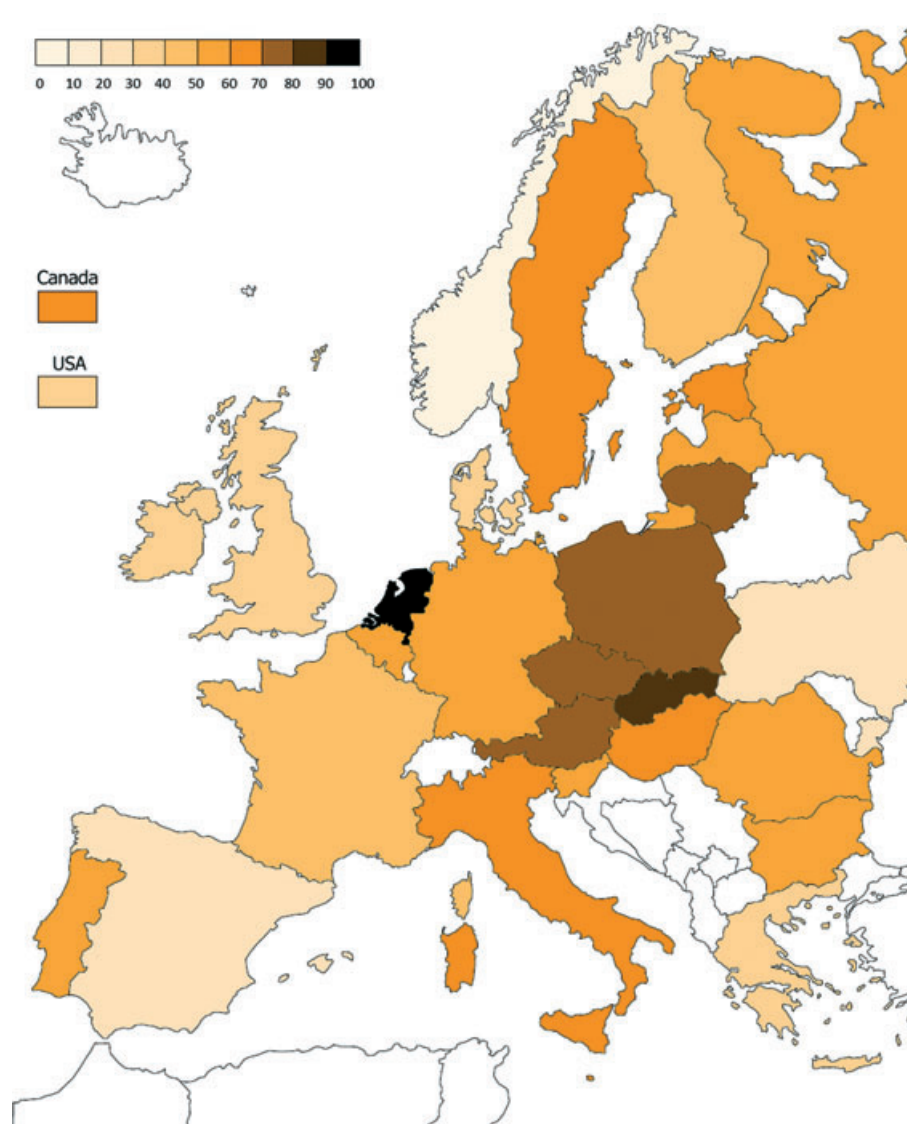


Figure 3. Wood pellet plant capacity utilization rate (%) by country in 2010.

Germany and Austria are almost entirely consumed for household heating. Both countries have high feedstock availability and therefore excess production for export. France follows a similar trend but with a much smaller excess in production. Similarly in Italy, the large majority of pellets are used for space heating in the residential sector; however, the domestic production can only fulfill approximately half of the total demand.

The production and production capacity of wood pellets in Germany is the highest in Europe. From the total production volume, about 75% is intended for the heating market (white pellets) and the remaining for electricity generation in the power plants. Over 90% of the white pellets are consumed within the country; however, the pellets used for power generation are entirely exported and not used in power stations

in terms of co-firing in Germany yet. In respect to the raw material used for pellet production, 70% were sawmill by-products as sawdust and 30% were low-quality round wood. The main export countries for industrial wood pellets (brown pellets) are the United Kingdom, Sweden, and Denmark. With respect to the trade of white pellets, the main trading partners are Italy and Austria for exporting and Denmark, Russia, the Baltics, and the Czech Republic as well as Belarus (a rather new trading partner) for importing brown and white pellets. In the past, the trade of wood pellets mainly took place with bordering countries as Austria and the Czech Republic. However, imports originate increasingly from Eastern European countries like the Baltics and Belarus.

In Austria, the production is sufficient to cover national demand, which is almost used for residential heating.

The trade of wood pellets mostly takes place in bordering regions. Austria exports mainly white pellets to Italy.

In France, pellet production has grown steadily since 2005. The development of pellet consumption is higher at the north-east part due to longer and colder winters. The potential availability of raw material is high, despite the fact that sawmills are small and sawdust resources are dispersed in a large territory. A factor causing a relatively slow development of the French pellet market can be identified in the prices of other sources of energy like gas and electricity, which are cheaper than in many other European countries. As the French electricity production is mostly from nuclear origin, its costs did not show any strong variations in these last years and electricity is promoted in France as claiming to have very low impact on the greenhouse effect. In fact, the international trading of wood pellets is negligible in France.

In Italy, the national production fulfills approximately half of the demand. In the last 2–3 years, several manufacturers have experienced difficulties in sourcing feedstock at competitive prices, mainly due to the rising competition from other manufacturing activities such as manufacturing of fiberboards and furniture, and also due to the increasing competition between a growing number of biomass plants, that in some cases have led to a concentrated demand of feedstock in some local areas.

The Finnish wood pellets production has been declining since 2008, but the consumption is still increasing. In 2009, about 40% of the domestic consumption of pellets in Finland took place in small boilers whose thermal output is less than 25 kW.⁸ Pellets have not been competitive with heavy fuel oil or coal as fuel in heating and power plants, and they are mainly used in applications where light fuel oil is an alternative fuel, typically in the heating of dwellings and small public or industrial buildings. In 2007/2008, pellet prices in Finland increased, approaching the prices of Sweden and Denmark. One explanation for the increase in pellet prices in Finland has been the rapid decline in the forest industry in 2008, which resulted in a raw material shortage in pellet mills and led to several stoppages in production. The narrowing difference of pellet prices between Finland, on one hand, and Sweden and Denmark weakens the attractiveness of pellet export to these countries.

Power plants driven market – the Netherlands, Belgium, and the United Kingdom

The large increase in the demand for industrial pellets for co-firing in northern/western European countries such

as the Netherlands, Belgium, and lately the UK, is driven mainly by the availability of feed in premiums for green electricity and the relative cost competitiveness of biomass with the cost of coal plus CO₂ emission allowances. This also applies to Denmark which was discussed earlier. The prospects for market growth in this segment are very positive, though still heavily relying on the continuity and stability of the supporting policy framework in the respective countries. These three countries share the same characteristics in that the national consumption is much higher than production. Similar to the Danish case, the Dutch production of wood pellets is relatively very small, far less than the consumption, given the limited availability of feedstock. Belgium and the UK have also shown similar trends. Almost 100% and 85% of wood pellets are used for co-firing in large-scale coal-fired power plants in the Netherlands and Belgium, respectively. Wood pellets produced in Belgium are mainly used in the residential sector. The consumption in the UK as reported in Ofgem is approximately 0.8 Mt in 2010/2011.⁹ Imported wood pellets for co-firing are mainly imported from Canada and the USA, and also partly from Baltic states, Russia, and other EU countries. Over the years, development of certification schemes has become a crucial issue for wood pellets used for co-firing.

Mixed market – Sweden, Denmark, and Poland

Consumption in Sweden is the highest in the world, with 34% consumed by private households. The production capacity has almost doubled from 2004 to 2010; however, there is still a net import of 0.7 Mt. The largest producers in Sweden use fresh sawdust, shavings and dry sawdust as feedstock for pellet production. The majority of the small-scale producers use only by-products from other activities while the large- and medium-scale producers mainly use purchased raw material. Raw material shortage is a recurring problem and several producers have difficulties in sourcing their feedstock. The reasons for such difficulties lie in the high raw material prices and intense competition (with wood industry). To fulfill the deficit in domestic supply-demand, wood pellets were imported from mainly Russia, Estonia, and Latvia.

The Danish production is very small compared to consumption, mainly due to lack of raw materials. Power plants consumption has increased steeply in 2010 (>50% of the total consumption) to overtake the private consumers. This is due almost exclusively to the establishment of Avedøre Unit 2, which consumes large amount of wood pellets. The main suppliers for the Danish market

are the Baltic States, Poland, Sweden, Canada, and Finland.

In Poland, the pellets market is still very young but growing fast. About two-thirds of the wood pellets were consumed in co-firing while the rest in residential heating, according to the ratio in 2009. The majority of pellet plants are small or medium-sized companies that buy their raw materials from wood processing industries (mainly wood shavings and sawdust) in their vicinity with their own regional distribution system.

Export-oriented countries

Countries with large raw material potential and small demand have developed an export-oriented pellet industry, particularly eastern and southern European countries. Russia is the largest wood pellet exporter in Europe. Most of the Russian pellets are exported to the EU. Northwest Russia contains 60% of forests in the European part of the Russian Federation; 17% of all Russian timber is concentrated in this region. Approximately half of the pellet mills are located in the Northwest region, which is geographically closest to Europe, and therefore facilitates the export to the main European commodity markets. Major internal consumers are private customers, but recently some municipal boiler-houses have been transferred from gas to pellets.

Portugal and the Baltic States are also major exporters in Europe, with little or negligible domestic consumption. The Baltic States mainly export wood pellets to Sweden and Denmark. Spain, the Czech Republic, Slovakia, Romania, Hungary, Ukraine, Lithuania and Croatia, each produce approximately 0.1 to 0.2 Mt in 2010.

North America

Bestowed with plenty of wood resources, Canada has been playing the role of wood pellets supplier and exporter since the Canadian domestic market is relatively small. In 2010, most of the pellets were exported offshore (1.25 Mt), about 75% to Europe, and the other quarter to the USA. Canadian pellet production declined in 2008, largely due to the shortage of mill residues as a result of sawmill closures brought on by a severe downturn in the US housing market and subsequent decline in demand for sawn wood. At that time shipping rates were exceptionally high, but are now back to normal. Eleven plants are located in British Columbia, with more than half of Canada's capacity, mostly in the interior (400–600 km from the ports). Canada is aware of the Swedish model whereby large capacity was built initially to supply large power plants,

and with assured pellet supply, a domestic heat market was subsequently built over time. The country anticipates utilizing its forest resources to build capacity for exports, but over time an increasing amount will be used domestically.

In 2010, over 80% of pellets produced in the USA were used domestically (1.6 MT); of the remaining, were exported to Europe (0.4 MT). A number of new mills have been built recently to process chipped round wood, especially in the wood basket of southeast USA. Their independence from the sawmill industry has allowed a focus on export of wood pellets, and many of the newer plants have capacities of several hundred kt per year. One reason for the availability of raw materials is the lower demand from a declining paper and pulp industry. A combination of factors such as a large availability of feedstock at competitive prices, as well as a sound and sustainable forest management system, relatively easy logistics, and cheap transport has rapidly attracted investment in the southeast USA from American as well as European companies. As a consequence, recent additions have brought the total capacity to around 6 Mt in 2010 and several new projects are in the pipeline. A large share of the US pellets from the southeast USA has been exported to Europe: according to EUROSTAT, exports to EU reached over 0.75 Mt in 2010, driven mainly by the demand for industrial pellet by co-firing plants in northern EU countries and to a much lesser extent by the increasing demand for residential heating in Italy.

Pellet prices in the USA vary by season, region, supply, and demand in the same way other heating fuels do. The selling price ranged from \$219 to \$280 per ton in recent years. Due to the collapse of the Euro in 2010 and financial difficulties in several EU countries, prices of North American industrial pellets have declined significantly. Canadian pellets have declined from \$154/t to \$125/t.

East Asia

In Japan, pellet plants vary greatly in size (50–3000 T) and have relatively small capacity compared to other countries. The residential heating market remained small due to insufficient raw material, lack of policy support and technical quality support.¹⁰ However, strong further growth is anticipated for co-firing – in 2010 Mitsui announced plans to import up to 0.4 Mt of pellets per year. Besides importing from Canada, import of a few hundred thousand tonnes industrial pellets from Western Australia was also expected starting from 2011.¹¹

In 2010, the South Korean market was rather small; the pellets plants themselves were all extremely small. Imports have almost tripled since 2007, mainly from China, Vietnam, and Malaysia, but the purpose of pellets use

remains unclear. For energy purpose, pellets are only used for boilers, and not yet for power generation. However, the pellet market is expected to grow rapidly starting in 2012 due to the government's newly introduced renewable energy portfolio standards requiring power companies to increase the proportion of renewable electricity production. The Korean Forest Service plans to secure supply from Indonesia, New Zealand, and Myanmar by assisting these countries to install pellet operations.

In China, the pellet market is still in its infancy, but the potential is huge. Although the consumption in 2010 is reported to be 0.6 Mt, 85% of these pellets are based on agricultural residues which differ significantly from wood pellets. The production sites reported on the Internet are small (0.01–0.05 Mt) and highly dispersed across provinces – Jilin, Henan, Inner Mongolia, Guangdong, Shandong, and Jiangsu, mostly utilizing wood and agricultural residues. Over the years, the wood industry has grown rapidly as a consequence of rapid industrialization in China. Forest and wood residues availability in China was roughly estimated to be 200–300 Mt in 2004 and half of this was reported as wasted or unused.¹² The amount of untapped wood residues may be up to 10 times current wood pellets production. On the other hand, the stoves, boilers, and pellet mills manufacturing sector seems to prosper in China. It is similar to other manufacturing industries: largely export oriented. Various regional policies and public investment were reported to facilitate the development of the wood pellets industry, and some foreign investments were also reported, but most of them are of very small scale.

South America

Brazil and Chile are currently the only two countries involved in the wood pellet industry. Brazil wood pellets are generally made from compressed sawdust. The current annual production capacity is slightly more than 0.3 Mt.¹³ The wood pellets were expected to be used domestically. However, there are several plans to expand production capacity. If these plans are to be realized, Brazil would become a major producer and exporter of wood pellets. Chile, on the other hand, has no long-term plans for wood pellets as yet. Theoretically, Chile has long-term potential for wood pellets: the country produces large quantities of sawdust and shavings and consumes large quantities of firewood for heating. However, the residues are currently largely utilized to produce electricity and heat (preference of the forest owners); and no subsidies exist for (high-quality) stoves, which are considered expensive in the country.

South Africa

South Africa has seen a plantation-oriented wood fuel and pellet production for export.¹ Due to the rapid wood consumption in the construction sectors before 2008 (in the preparation for FIFA World Cup), large amounts of wood residues have stimulated the growth of wood pellet manufacturing in South Africa. Nevertheless, it only serves as an exporter. After 2008, the wood consumption dropped drastically, causing the collapse of wood pellet manufacturing. Out of three companies operating in 2009, two went bankrupt while the remaining market party is not operating at maximum capacity due to problems with impurities.

Oceania

The first pellet production plant began operations in Australia in 2009, with a capacity of 125 kt per year.¹⁴ In 2010, there were several projects and plants in Australia and New Zealand that manufacture wood pellets for the European and Japanese markets, primarily to the Netherlands and Denmark. Plantation energy in Western Australia produced 0.25 Mt in 2010. However, the local market is still in its infancy. In Australia, pellets are mainly used for residential heating, although there are an increasing number of commercial-scale users using pellets to generate electricity. The potential for heat and power from pellets in Australia is huge but is yet to be fully realized due to a lack of incentives and long-term policy certainty.¹⁵ In New Zealand, wood energy is mainly used by the timber industry, which burns residue wood to provide heat energy. However, there is still no large-scale production and consumption of wood pellets.

In 2011, Australian pellet production and exports came to a halt.¹ So far, the installed capacity (0.25 Mt) has not been fully utilized as the industry has seen cases of bankruptcy and still tries to overcome early market issues, such as fluctuating exchange rates and high shipping costs. Small-scale production of high-quality wood pellets for the residential heating market in Australia exists but is still only at around 5 kt installed capacity. However, the supply potential is high – it is estimated that Australia and New Zealand could expand their annual production (and export) capacity to 1 Mt and 0.5 Mt, respectively, by 2020.⁵

Market analysis and outlook

Market factors and intervention policies

Each individual wood pellet market has its own characteristics in terms of resource availability, geographical

factors, climate, and economic factors. Ultimately, the markets for industrial use are especially shaped by cross-country variation in policies development. Looking across these individual markets allows for the identification of basic underlying issues. Table 1 summarizes the market characteristics and policies framework by country and how these shape the market trend.

Based on the overview of markets, we postulate that next to support policies, the two most important factors that determine the demand for wood pellets are: (i) the presence of coal power plants and (ii) types of residential heating systems.

In the first situation, industrial wood pellets are traded for co-firing with coal in power plants. This is reflected in the increased pellets consumption for co-firing in Belgium, the Netherlands, the UK, and Denmark, mainly driven by government policies. East Asia, particularly Japan and South Korea, have set targets in their Renewable Portfolio Standards, which have stimulated co-firing of wood pellets in large coal power plants. Both countries are expected to experience strong growth in consumption in the next few years. On the other hand, biomass-rich countries such as France and Norway, which have no coal power plants (but nuclear power / hydropower-oriented electricity production, respectively) have no large-scale use of pellets for electricity production. However, the presence of coal power plants is only one precondition, but does not automatically lead to co-firing; policy intervention is the ultimate controlling factor. For example, wood pellets in Germany are almost entirely consumed for household heating due to specific supportive measures from the governments, i.e. no support for large-scale use of wood pellets, despite the existence of a large number of coal power plants. Similarly, in Poland, to our knowledge only one plant out of several dozen co-fires woody biomass. However, if policymakers decide to go for large-scale electricity production from biomass, the presence of coal power plants can enable a swift and low-capital-intensive shift to electricity from biomass.

In the second case, well-developed decentralized heating-oil-based household heating and district heating

systems provide opportunities for the use of high-quality wood pellets. Especially due to the high (heating) oil prices, replacing an oil boiler with a pellet boiler can be an economically attractive alternative for households, as has been the case in Italy, Austria, Germany, Denmark, Sweden, and Finland.[§] The development can be further supported by a dynamic stove and boiler manufacturing sector, such as in Italy. Support policies have again been crucial to support the diffusion of wood pellet stoves. In some cases heavy taxation is applied on fossil fuels; in other cases, subsidies and incentives are given to wood pellet consumers. This intervention has successfully stimulated market growth, but the continuity of such policies has been questioned. Uncertain future policies due to depletion of budgets imply an unstable market. One example is Germany where the freezing of MAP budget has caused a smaller number of pellets heating systems installed in 2010.

On the wood pellet supply side, three main interrelated factors are: (i) resource availability, (ii) interactions with the wood industry, and (iii) logistics issues. Generally, countries with vast raw material potential have a low population density, and therefore the resources are often dispersed in a large territory and difficult to access, such as Russia and Canada. In addition, the interactions with other wood product industries are crucial in countries with strong wood-based industries (e.g. panel-board manufacturing). Intense competition for raw materials may occur in some countries, such as Sweden and Finland. Despite that, operational experience, processing facilities, and transportation infrastructure developed by the existing wood industry provide a perfect basis for the development of a wood pellet industry. Public and private investments could be the key factor such as foreign investment in the Baltic States, and recent investment in large projects in Russia. Scaling up of the project may help to overcome the logistics barriers as this may significantly reduce the cost of transportation per unit. Intervention from the authorities could be very direct, such as financial incentives (to stimulate production) and export duties (to control the flow of pellets or raw materials, such as round wood).

Perspective on sustainable wood pellets – opportunities and challenges

Currently, the wood pellet market is largely influenced by national policies. Apart from policy intervention, the opportunities and challenges for the wood pellet industry can be analyzed based on four primary aspects: (i) supply potential, (ii) logistics issues, (iii) sustainability

[§]In countries with a comprehensive natural gas grid, wood pellet heating is less successful, for several reasons: natural gas is often considered to be a clean fuel in the first place, so policymakers are less inclined to have it replaced by wood pellets. Second, natural gas boilers are nowadays very small, requiring very little room – contrary to a wood pellet boiler, that requires several cubic meters of storage space. The latter is especially a limiting factor in densely populated countries such as the Netherlands, and densely populated urban areas in general.

considerations, and (iv) technology development. These four issues are intertwined with each other and hence it is important to look into each aspect not only separately, but also collectively to see the opportunities and challenges that may determine future markets.

The authors expect that pellet demand will experience a steady growth in Europe and possibly a very strong growth in East Asia. Thus, securing the supply will become the main challenge, as raw materials resources will become increasingly scarce. Figure 4 shows the anticipated growth in available solid biomass supply from the various sourcing regions in a business-as-usual scenario.^{5,17} Canada and the USA are expected to remain the main suppliers. British Columbia is currently one of the largest sources of wood pellets. In the southeast USA, besides sourcing from wood residues, southern pines are also used as energy crops. In Eastern Europe, in the past few years, the Russian wood pellet market was rather turbulent and erratic. The authors expect that growth of Russian wood pellets will largely depend on large private investment in large pellet plants, for example, the Vyborgkaya plant with a production capacity of 0.9 Mt.¹⁶

In the next few years, Japanese and South Korean co-firing projects may create a new market for Canadian pellets. To the authors' knowledge, there are (still) no sustainability requirements from Japanese and South Korean authorities. This may further stimulate the shifting of Canadian pellet export destination from Europe to East

Asia. Otherwise, this new growth of demand will induce more pellets production in Southeast Asia and Oceania.

In the high-import scenario, the authors assume that the demand for wood pellets in the EU and abroad will increase rapidly, triggering investments in additional wood pellet plants based on feedstock from new plantations using short rotation crops.^{5,17} Assuming that short rotation woody energy crops will probably be established in the same regions as currently pulp plantations are established, i.e. in South America (Brazil and Uruguay) and Africa (Western Africa and Mozambique), together with the utilization of round wood in northwest Russia, the authors postulate an additional biomass supply of up to 17 Mt (Fig. 5).

There are also efforts in sourcing new raw materials for pellets in Europe itself, which is currently the largest market. Pellets made from agricultural residues (agropellets), are co-fired in power plants in Denmark, the UK, and Poland. However, due to the fact that sources of agricultural residues are highly dispersed, it seems to be more suitable for small-scale district heating. However, the higher emission of particular matter, HCl and SO₂ in boilers compared to wood pellets has limited the use of agropellets at this moment.¹⁸

From a logistics point of view, cost barriers and greenhouse gas emissions from transportation are two major issues. This is exemplified in two parts: (i) long-haul inter-continental trade, and (ii) sourcing of raw materials from inland. The issue lies within the compatibility of wood pel-

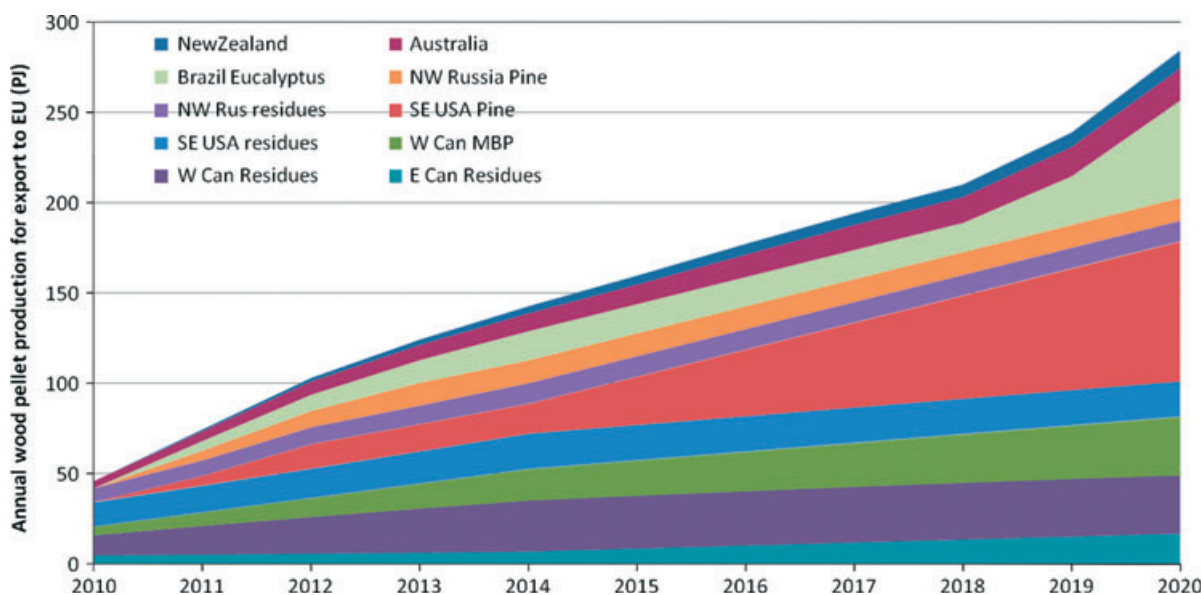


Figure 4. Anticipated growth in available solid biomass supply from the various sourcing regions. Residues = woody industry residues (e.g. sawdust), MPB = Mountain pine beetle affected wood. For comparison: 1 Mt of wood pellets equals about 18 PJ.

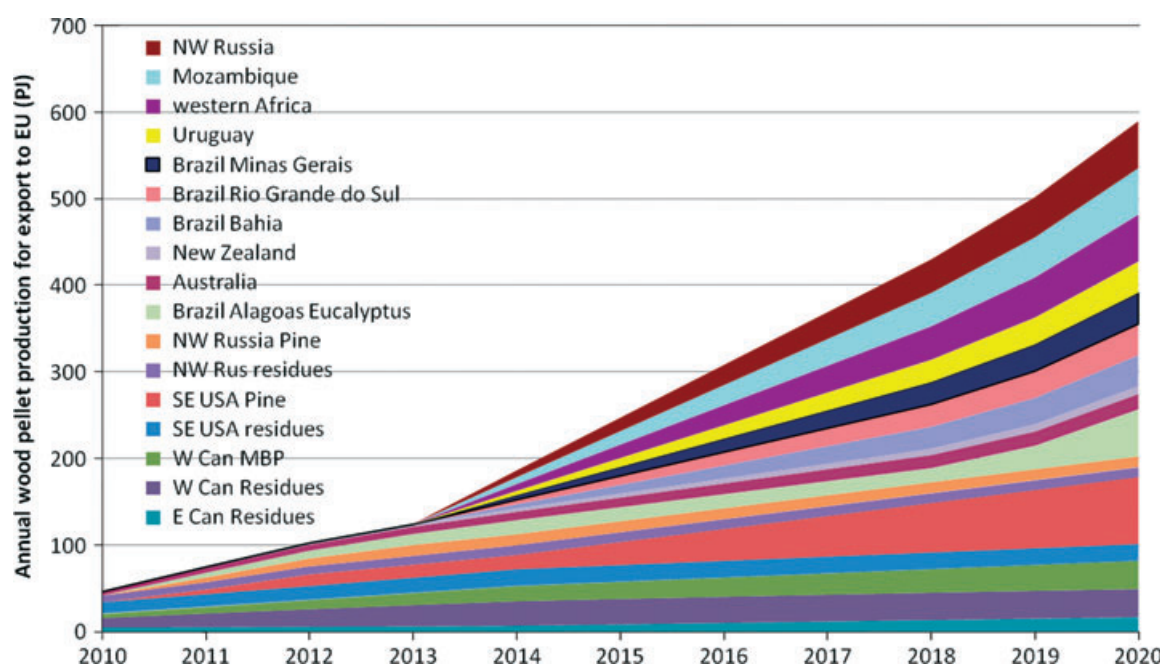


Figure 5. Anticipated growth in available solid biomass supply from the various sourcing regions in the high import scenario from 2010 to 2020. For comparison: 1 Mt of wood pellets equals about 18 PJ.

lets with current port facilities (mainly designed for other commodities) and inland transport network. Wood pellets have a lower economic value compared to coal, adding extra costs in handling and storage. In addition, the safety aspect may also play an increasingly important role, especially for the storage of wood pellets. There are several ongoing innovative developments to improve the logistics, such as the integration of wood pellets in coal transportation.

As also reflected in the issues already discussed, sustainability is likely to emerge as a primary consideration in wood pellet trade in the near future, especially for the EU market. Different supportive measures with a sustainability consideration in the supply chain have been employed. Belgium and the UK have implemented sustainability regulations that cover the whole biomass chain in an integrated way. The Netherlands currently has no binding criteria for solid biomass, but it may well be possible in the future that new policy support for wood pellets will be linked to legislation based on these principles. To ensure that bioenergy produced from wood pellets contributes to the reduction of greenhouse gas while not imposing other threats to the environment, various standards and certification schemes have been established to monitor the whole chain. From the market development perspective, unreasonable requirements may further limit the biomass supply, preventing growth of the industry. A noteworthy example would be the recent discussion over the definition

of 'primary forest' in the context of Canada.** Applying a generic definition of primary forest on Canadian forests without considering local conditions and scientific knowledge may create unnecessary barriers to mobilization of sustainable biomass supply chains in Canada. A science-based approach built with local knowledge is therefore crucial in developing sustainability criteria. Furthermore, more clarity on sustainability criteria will create security for long-term stable market and trade development.

At the time of writing, the EU-RED has not yet introduced sustainability criteria for solid biofuels, while numerous voluntary sustainability schemes are being developed or implemented. To improve the efficiency and credibility of the market, harmonization of these schemes may minimize confusion among the market actors and reduce unnecessary cost burdens.¹⁹ To secure flexibility in supply and demand and to minimize uncertainties, main industrial wood pellets users have

** In the current UK sustainability criteria for solid biomass (in which it applies an adapted version of the criteria in the EU-RED meant for liquid biofuels, which in the near future may also be enforced for solid biomass), it is said that biomass must not be sourced from 'primary forests'. In the context of Canada, where forest management is not intensive and forest landscapes are largely driven by large-scale natural disturbances such as fire and insect epidemics, it is very hard to operationally identify primary forest. According to the current definition (given from FAO), large forested area in Canada may potentially fall under this group.

initiated an effort to harmonize various sustainability certification schemes for wood pellets, namely IWPB initiatives. A harmonized sustainability certification scheme would improve the flexibility of biomass-fired power plants in managing their supply. As they rely on long-term procurement contracts, it is in the plants' best interests to re-trade their wood pellet supply horizontally between each other, when there is excess or shortage in supply. Hence, contract forms and legal conditions must be harmonized to ensure appropriate trading conditions.

Two sustainability concerns that have so far not been discussed extensively for wood pellets are the effects of (indirect) land-use change (iLUC) and the so-called carbon debt debate. With regard to direct and indirect LUC, with the increased use of roundwood in the USA, the Baltics and (proposed) Brazil for wood pellet production, all related issues debated so far almost exclusively for liquid biofuels may also apply for the production of wood for pellets. The carbon debt debate relates to the fact that carbon from biomass is released rapidly through combustion, but it may take longer (e.g. decades) before this carbon is recaptured from the atmosphere by renewed tree growth. Both debates are complex and multifaceted, so we refer to the literature for more details (the iLUC debate²⁰ and the carbon debt issue^{21–24}), but point out that both will likely require increasing attention by policy actors and market parties in the near future.

Technology development could be a possible solution to part of these issues. This could be further divided into three aspects:

- (i) Improvement in woody energy crops cultivation, to reduce the demand for land and shorten carbon pay-back times.
- (ii) Improvement in wood pellets quality and energy density to reduce GHG emission during transport, but also logistical problems.
- (iii) Improvement in conversion technologies to increase conversion efficiency and thus again reduce GHG emissions.

One interesting technology development that has come into focus recently is torrefaction. By increasing the energy density and pellets characteristics, it largely improves the efficiency in long-haul transportation (reducing both cost and greenhouse gas emission), it substantially lowers the costs for handling and storage, and increases the potential share of co-firing (higher end-use efficiency). Although there are still some technical barriers to overcome, the authors optimistically look forward to the development of pellet upgrading technologies as the breakthrough of wood pellet industry occurs.

To sum up, the authors expect the market will be further expanded, especially in East Asia, although the EU will still remain the main wood pellets market. China is the biggest wild card, with high potential not only in raw material availability but also in market development. The EU is leading the development and also the harmonization of sustainability certification schemes for wood pellets, which has become the one of the major factors in shaping global trade and market. Together with the anticipated breakthrough in pellets pre-treatment and production technologies, better sourcing of raw materials, optimization of logistics, and harmonization of sustainability certification should be the primary concerns in the near future.

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